TECHNOLOGY UTILIZATION

Rodney W. Johnson
Manager, Experiment Payloads
Space Station Task Force
National Aeronautics and Space Administration
Washington, D.C.

ESRO Briefing
Paris, France
June 3-5, 1970

2

TECHNOLOGY UTILIZATION

- ADVANCED TECHNOLOGY RESEARCH
- MSF ENGINEERING AND OPERATIONS
- SPACE PROCESSING AND MANUFACTURING
- AEROSPACE MEDICINE RESEARCH

NASA HQ MF70-6095
5-25-70

SLIDE 1

SUBJECTS COVERED

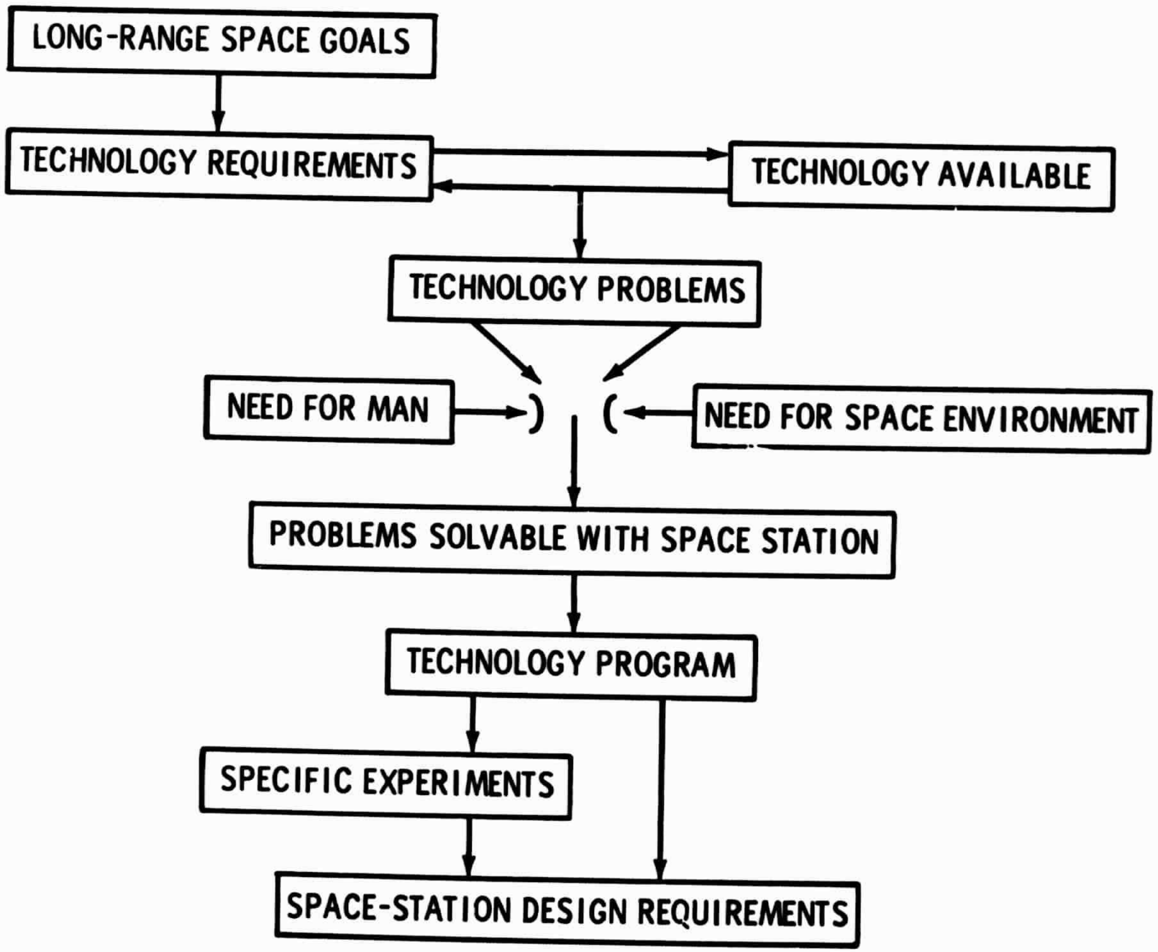
Technology utilization embraces four areas of Space Station activity:

Advanced Technology Research
MSF Engineering and Operations
Space Processing and Manufacturing
Aerospace Medicine Research

In all four areas, the Space Station will be used to accomplish development work leading to improvements in spacecraft systems and uses of expanded research capabilities which will become operational when the orbital complex expands its operations toward the size envisioned for the Space Base.

4

ADVANCED TECHNOLOGY RESEARCH

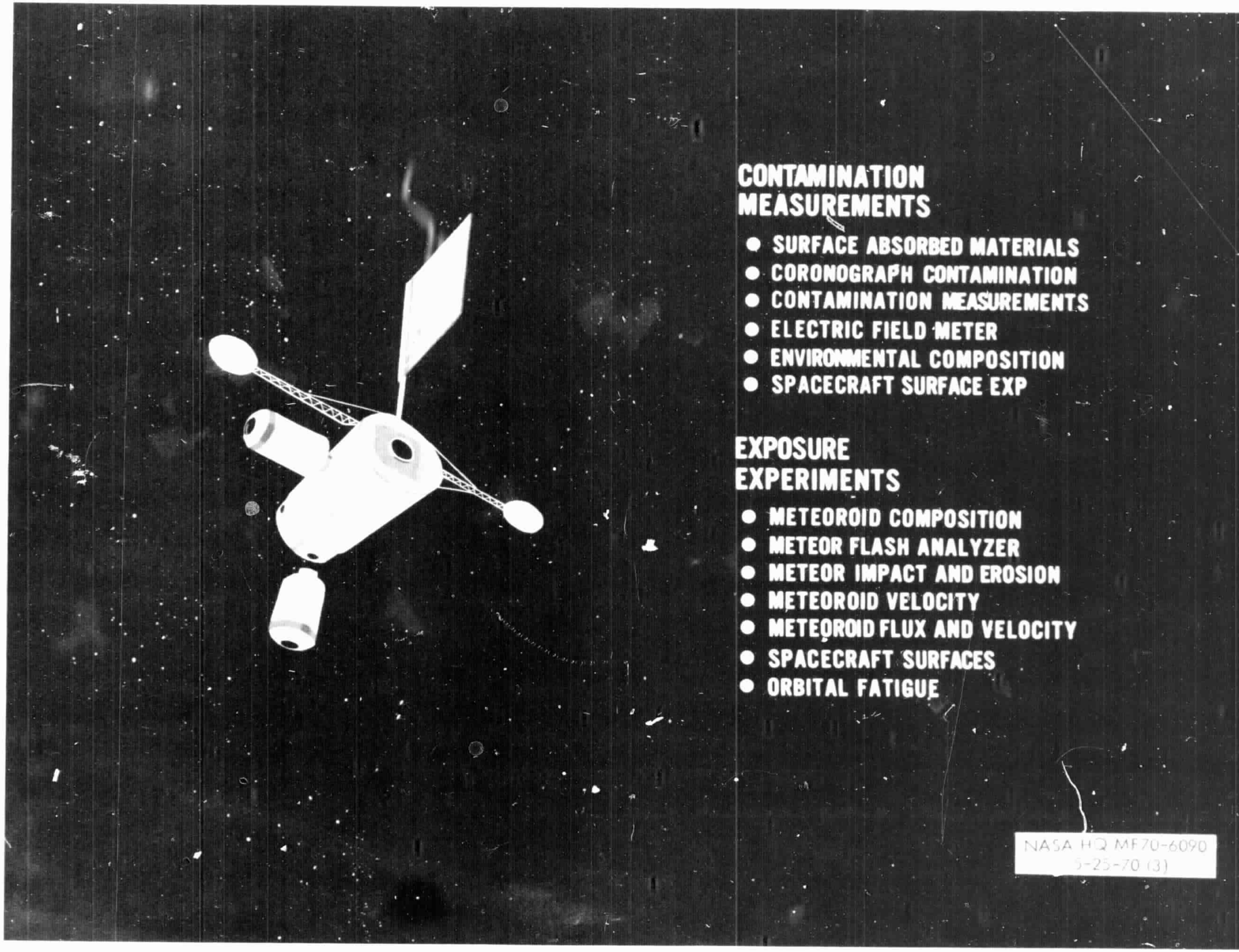


NASA HQ MF70-6094
5-25-70

SLIDE 2

ADVANCED TECHNOLOGY RESEARCH

This area of research concerns the kind of activity in which NASA will use its flight capabilities to develop increased capabilities for operations and experiment support for systems to be used later in the Space Base buildip and in other spacecraft elements of the Integrated Space Program. At the present time, the major emphasis has tended to focus around fluid physics research, advanced component and sensor tests and on studies of Space Station contamination. The early program discussed here is confined to things that can't be done elsewhere than in space, but as the Space Station expands and transportation and operational costs decline, we expect that many things will become cheaper to do in space than on the ground. For example, extended thermal-vacuum environmental tests will move out of simulators and into real space.



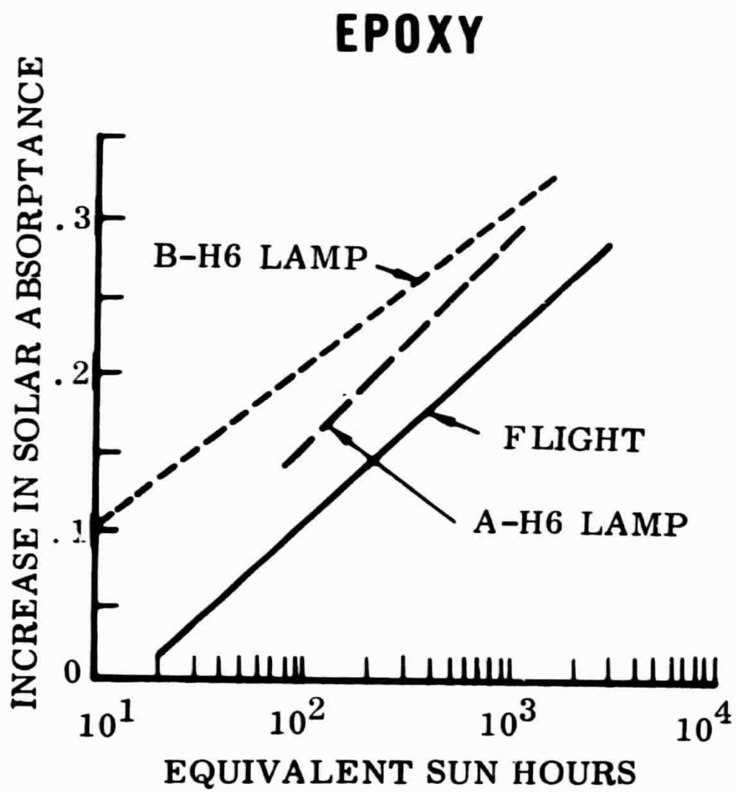
CONTAMINATION
MEASUREMENTS
● SURFACE ABSORBED MATERIALS
● CORONOGRAPH CONTAMINATION
● CONTAMINATION MEASUREMENTS
● ELECTRIC FIELD METER
● ENVIRONMENTAL COMPOSITION
● SPACECRAFT SURFACE EXP
EXPOSURE
EXPERIMENTS
● METEOROID COMPOSITION
● METEOR FLASH ANALYZER
● METEOR IMPACT AND EROSION
● METEOROID VELOCITY
● METEOROID FLUX AND VELOCITY
● SPACECRAFT SURFACES
● ORBITAL FATIGUE
NASA HQ MF70-6090
5-25-70 (3)

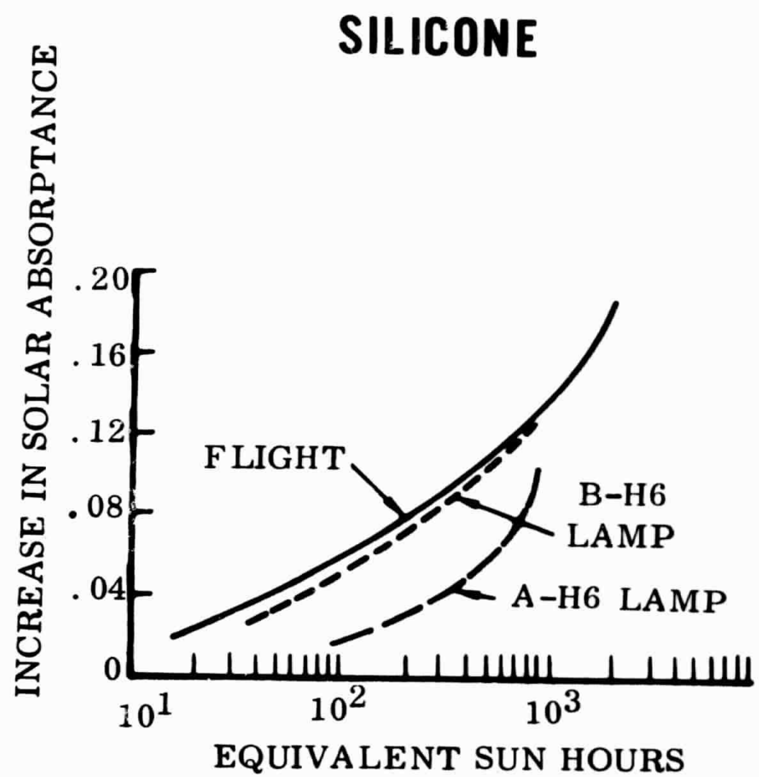
SLIDE 3

CONTAMINATION MEASUREMENTS AND
EXPOSURE EXPERIMENTS

Contamination measurements will typically monitor deposition of condensable species, determine how the actual environment affects instrument readings, condition of surfaces and identify composition of contaminants. Data will be useful for operational support and for design of future systems in which sources of contamination are eliminated or rendered harmless. Exposure experiments are mainly divided between measurements of meteoroid effects, which have been approached by previous unmanned programs such as Pegasus but which still involve uncertainties, and measurements of the combined environment on materials. The value of the Space Station for meteoroid experiments centers on the fact that they can be performed relatively easily on a spacecraft which combines large support facilities with the crew, thus providing flexible and resourceful operation of the equipment.

SYNERGY EFFECTS IN SPACE ENVIRONMENT





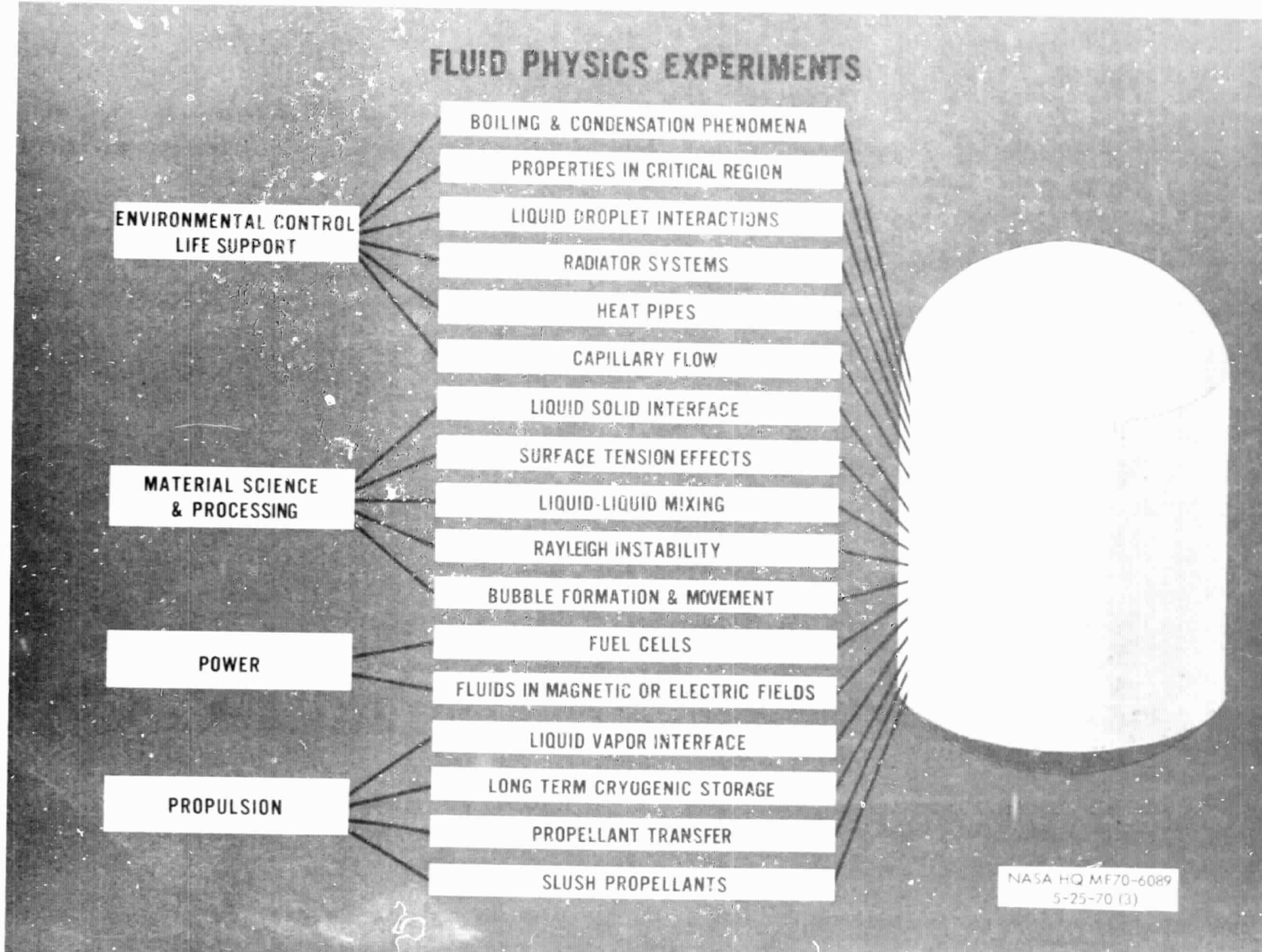
NASA HQ MF70-6085
5-25-70

SLIDE 4

SYNERGY EFFECTS IN SPACE ENVIRONMENT

Tests of the aging of materials exposed to the space environment are important because the proper functioning of the Space Station depends on the performance of its exterior structure and coatings - particularly on the thermal control coatings that help maintain its interior temperature. Though we expect to provide coatings and structural materials for the Space Station that will last for a long time, we cannot be sure just how long they will last or exactly how rapidly they will be degraded, because it is very difficult to simulate the space environment on the ground. This slide gives an example of this difficulty. It shows data on the progressive darkening of a titania-epoxy and a titania-silicone coating, obtained with two different solar simulator lamps and compared with actual flight. The differences between the flight and simulation data are quite significant in the two cases, and are opposite for the two materials; the epoxy-based material behaves better in flight than in simulation, while the silicone-based material performs poorly in flight.

10



FLUID PHYSICS EXPERIMENTS
ENVIRONMENTAL CONTROL LIFE SUPPORT
MATERIAL SCIENCE & PROCESSING
POWER
PROPULSION
BOILING & CONDENSATION PHENOMENA
PROPERTIES IN CRITICAL REGION
LIQUID DROPLET INTERACTIONS
RADIATOR SYSTEMS
HEAT PIPES
CAPILLARY FLOW
LIQUID SOLID INTERFACE
SURFACE TENSION EFFECTS
LIQUID-LIQUID MIXING
RAYLEIGH INSTABILITY
BUBBLE FORMATION & MOVEMENT
FUEL CELLS
FLUIDS IN MAGNETIC OR ELECTRIC FIELDS
LIQUID VAPOR INTERFACE
LONG TERM CRYOGENIC STORAGE
PROPELLANT TRANSFER
SLUSH PROPELLANTS
NASA HQ MF70-6089
5-25-70 (3)

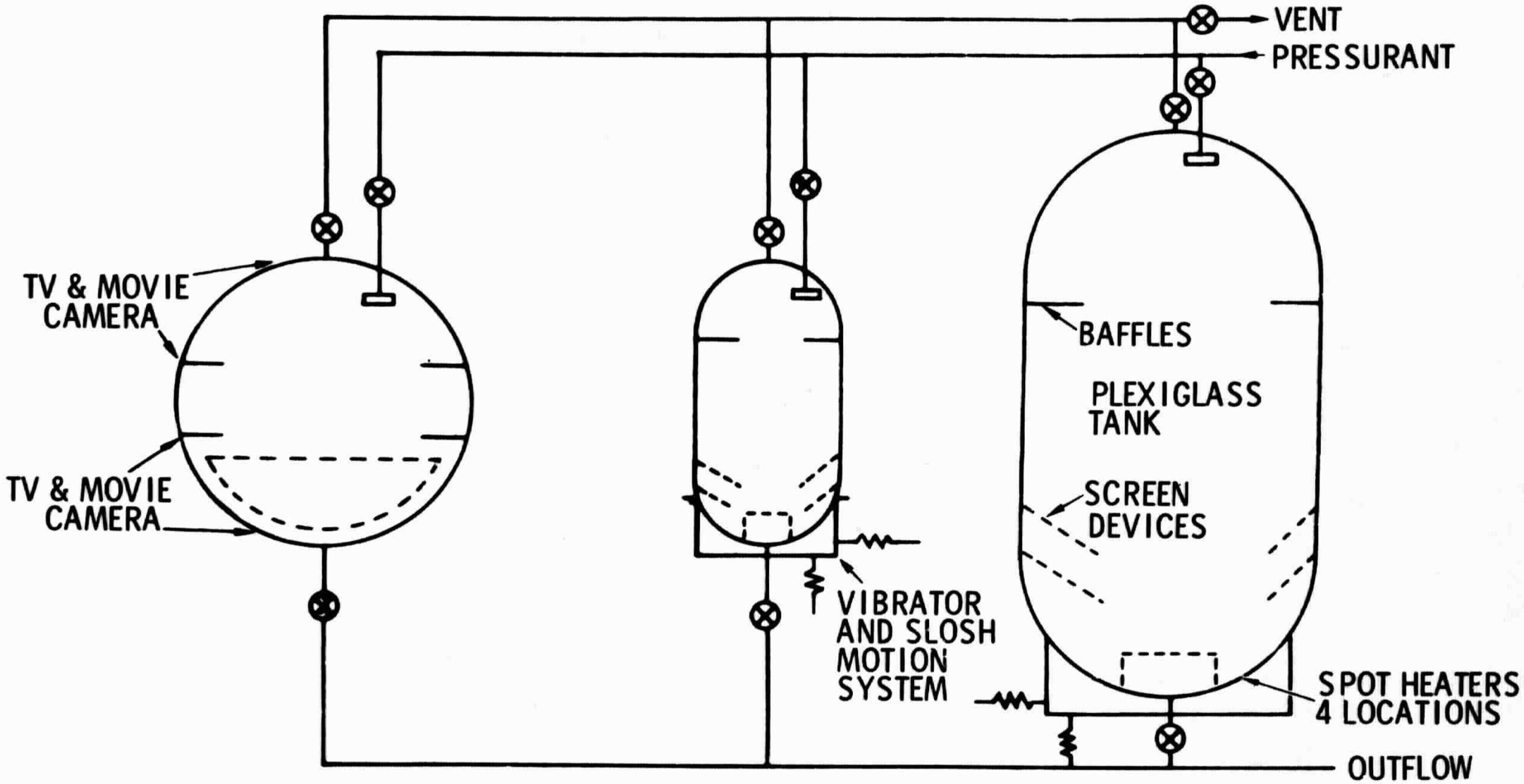
11

SLIDE 5

FLUID PHYSICS EXPERIMENTS

Although NASA has been successful so far in designing heat exhangers, propellant systems, and the like, that function successfully in space, optimum design of equipment for future long-term missions such as free-flying module operations with replenishment of propellants or planetary missions involves engineering questions for which adequate design data are not yet available and cannot be obtained on the ground. We therefore plan a large Fluid Physics Laboratory to study the mechanical and thermodynamic behavior of fluids in detail on the Space Station. As this slide demonstrates, there are many areas in which advanced fluid physics research will advance as technology; the laboratory facility concept is intended to accommodate not only these typical experiments, but any others which subsequently may be desirable.

INTERFACE STABILITY AND BUBBLE GROWTH



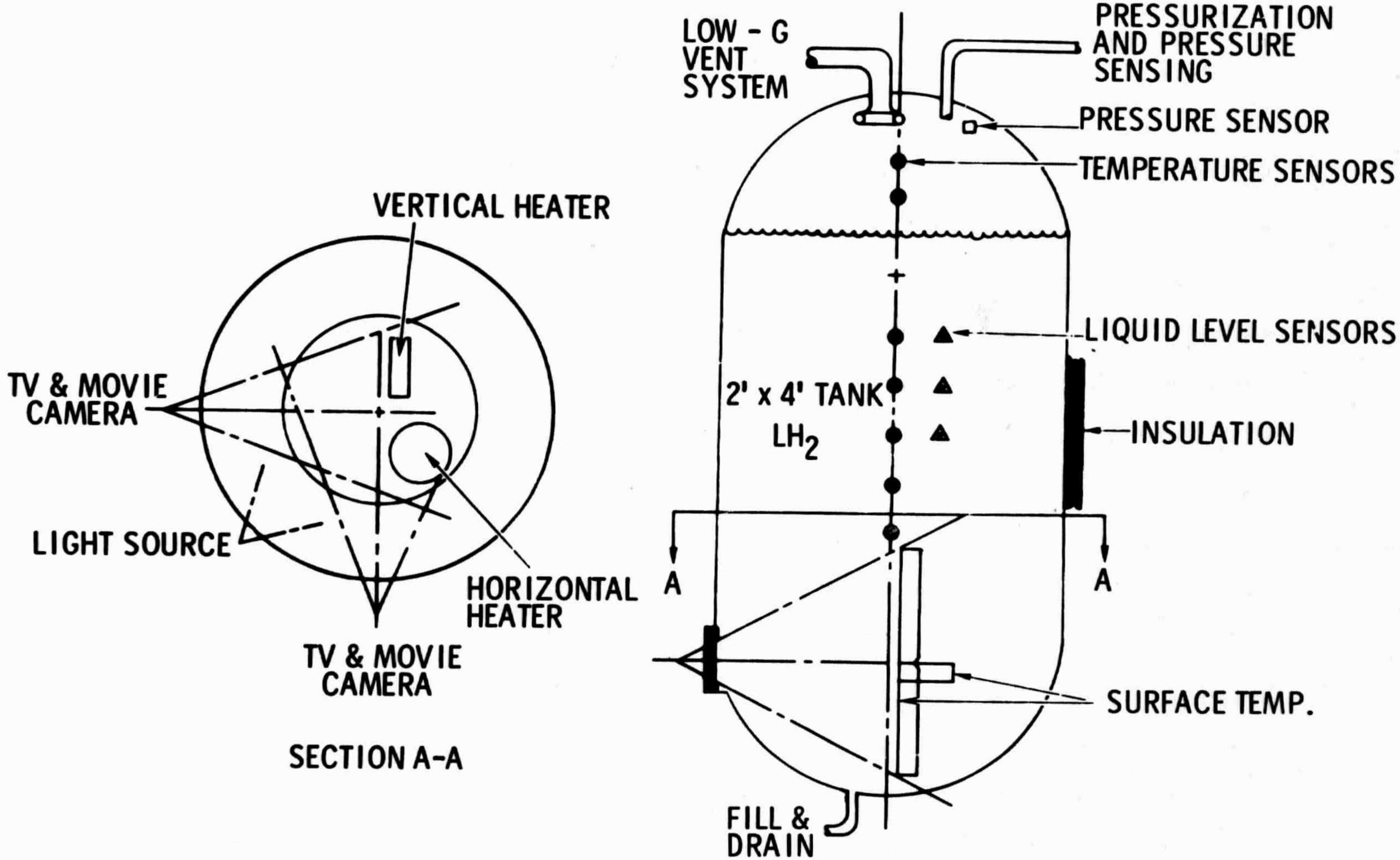
NASA HQ MF70-6083
5-25-70

SLIDE 6

INTERFACE STABILITY AND BUBBLE GROWTH

One example of the kind of facilities planned for the Fluid Physics Laboratory is shown here which is a schematic layout of a system for studies of liquid-vapor interfaces and bubble behavior in fluids stored in tanks under micro-gravity conditions. The tanks will be made of transparent plastic, with provisions for replacing the screens and baffles indicated inside them, and the experiments will be performed with storable liquids such as alcohols, hydrocarbons, or Freon. Typical topics to be studies will involve (1) fluid transfer between tanks, (2) large-amplitude sloshing such as would result from resonant vibrations or attitude changes, (3) methods of reórienting liquid tanks, (4) breakup of unstable liquid-vapor interfaces, and (5) the growth, motion, and interaction of bubbles. All of these effects will be important in handling fluids which are stored for long periods in space. Moreover, we expect these experiments to be of value in developing fluid-handling methods for cases in which it will not be permissible to consolidate the liquid floating in a tank by applying a sudden acceleration, as is common now with restartable rocket engineers.

BOILING HEAT TRANSFER EXPERIMENT



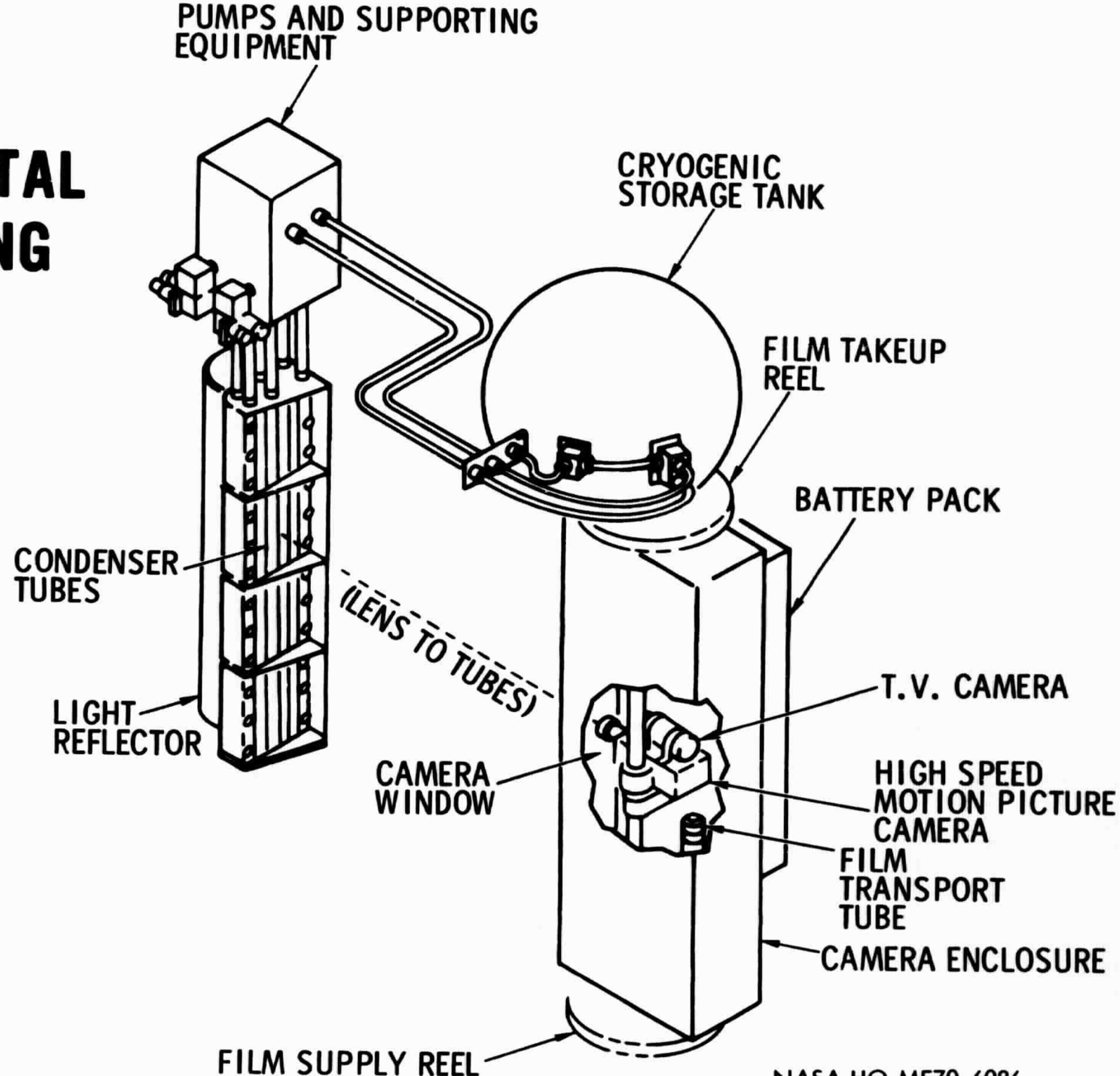
NASA HQ MF70-6084
5-25-70

SLIDE 7

BOILING HEAT TRANSFER

This is a schematic diagram of apparatus for work on the boiling behavior of liquid hydrogen at very low acceleration levels. In a tank where hydrogen is stored for a long period and slowly consumed, the normal steady-state equilibrium between liquid and saturated vapor will be disturbed fairly often by withdrawals of liquid and venting of vapor. The pressure and temperature variations in the tank during the return to saturated boiling conditions will be governed by non-steady state heat transfer effects which include some unfamiliar factors associated with the growth and motions of bubbles at low acceleration levels. The only way of acquiring data which are precise enough for engineering purposes appears to be to study boiling heat transfer under actual conditions in an instrumented tank that is large enough to approximate the behavior of an actual storage system.

EXPERIMENTAL CONDENSING SYSTEM



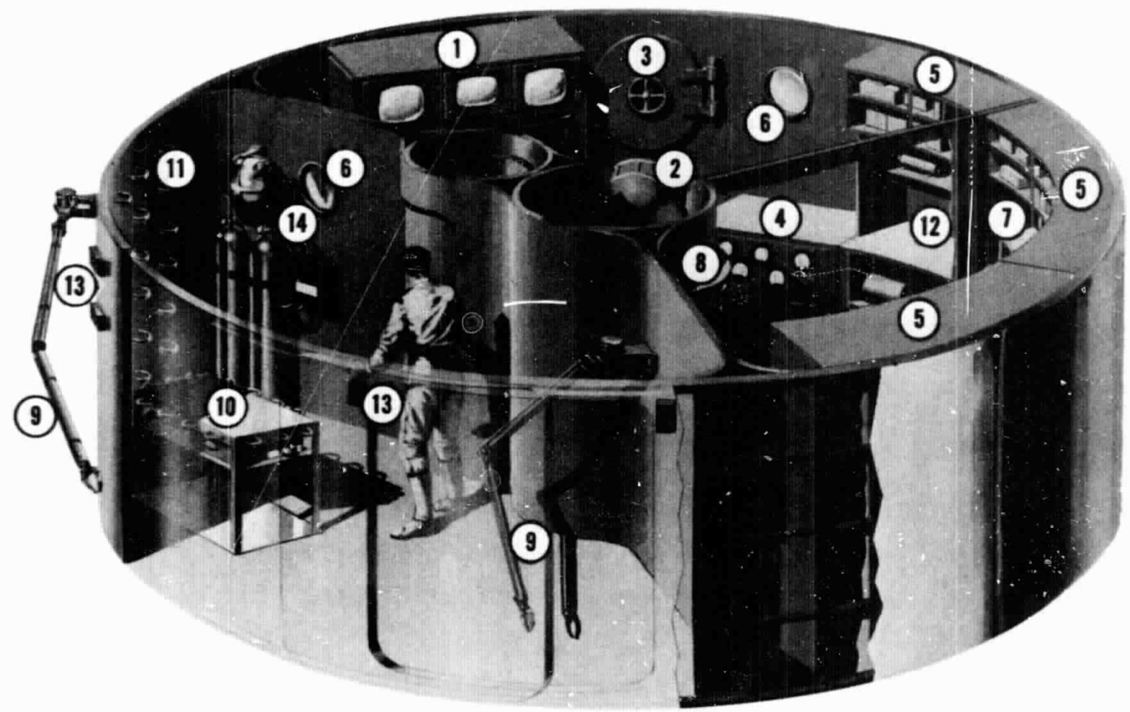
NASA HQ MF70-6086
5-25-70

SLIDE 8

EXPERIMENTAL CONDENSING SYSTEM

Slide 8 shows a concept for another device which can be used to study the performance of condensing heat transfer in a refrigerating system. In the unit shown at the left, Freon refrigerant will be condensed at various pressures and temperatures in transparent tubes having several different configurations. The pressure and temperature will be regulated using gaseous nitrogen supplied from the spherical tank shown at the top of the right-hand unit in the drawing. The behavior of the refrigerant will be monitored and studied by the movable cameras indicated in the right-hand unit, and by pressure and temperature sensors; the cameras will be arranged to scan along the lengths of the tubes.

R&D ADVANCED TECHNOLOGY LABORATORY



1. DISPLAY EQUIPMENT ASSOCIATED ELECTRONICS
2. EQUIPMENT AIRLOCK
3. LOGISTICS MODULE DOCKING ADAPTER
4. MASS SPECTROMETER
5. GENERAL PARTS & EQUIPMENT STORAGE RACKS
6. VIEWING PORT
7. FLUID HANDLING ENCLOSURE
8. EXPERIMENT RACKS (REMOVABLE)
9. MANIPULATOR ARM
10. TEST FIXTURE
11. EXPERIMENT MOUNTING BRACKETS
12. WORK BENCH AREA
13. EQUIPMENT MOUNTING PADS
14. INDEPENDENT ECS SYSTEM

NASA HQ MT69-4538
REV. 5-25-70

SLIDE 9

COMPONENT TEST AND SENSOR CALIBRATION LABORATORY

This slide shows an artist's concept of a deck of the Space Station configured for general-purpose test and calibration work. Generally speaking, we expect the facilities in this laboratory to be much like bench-test facilities on the ground, with supporting utilities such as regulated electric power, compressed gases, water, and cooling loops. Space will be available for setting up fairly large operating systems, and the design emphasis will be on providing maximum flexibility so that the laboratory's facilities can be used in many different configurations. In essence, this laboratory will be the Space Station's combined machine shop and standards laboratory. On a long and continuously evolving mission, the support provided by this facility to the experiment program is expected to be as valuable as that provided by similar facilities to laboratories on the ground.

MSF ENGINEERING AND OPERATIONS

TWO MAJOR THRUSTS
- OPERATIONAL SYSTEMS TESTS
- ADVANCED TECHNOLOGY AND DEVELOPMENT

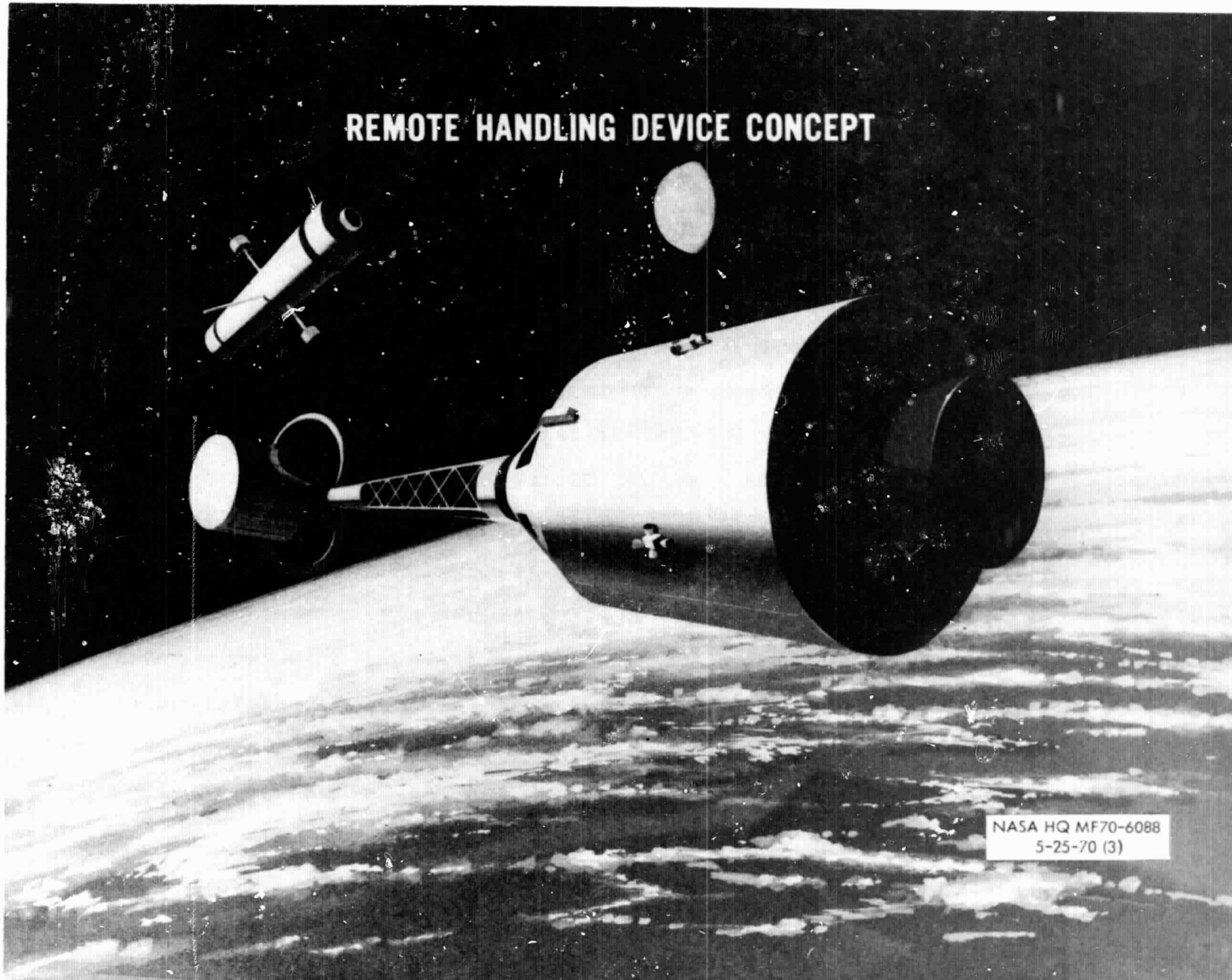
- PROPOSED EXPERIMENT PROGRAM CURRENTLY UNDER STUDY
  - EXTRA-VEHICULAR ACTIVITY
  - MAINTENANCE AND REPAIR
  - LOGISTICS AND RESUPPLY
  - FLIGHT CONTROL
  - LOSER COMMUNICATIONS
  - WIRELESS POWER TRANSMISSION

SLIDE 10

MSF ENGINEERING AND OPERATIONS

Because of the high cost of manned and unmmanned space systems, it is necessary that NASA take advantage of every avenue available to obtain data that can be used to better design future space systems and reduce the cost of the space program. The classical approach in obtaining data in an area of uncertainty is to design an experiment which can provide the data. This is costly but still the best way to obtain needed data in the space program. The MSF Engineering and Operations experiment program is directed at obtaining data in an organized manner using operational systems and techniques and is meant to supplement controlled experimental data but not replace it. It is difficult to define this class of experiments so far in advance of the operational date of the Space Station; by the time it becomes operational near-term engineering needs usually don't involve unknowns of such importance as to require experimental resolution, and pure engineering tests tend to become mission engineering objectives, which fall under operations rather than experiments. Since our planning has not yet gone into mission requirements beyond the initial Space Station module in very great detail, we can only describe some specimen activities that show what kinds of tests the module may have to support.

22



SLIDE 11

REMOTE HANDLING DEVICE

One of the important operational functions that a permanent manned space facility can perform is to maintain or modify unmanned satellites, thus considerably extending their operating life and usefulness. Slide 11 shows one current concept of a device for recovering an unmanned satellite so that it can be cought on board a manned spacecraft. The system consists of a boom mounted on the nose of a Command Module or other spacecraft, with a large pair of rotating tongs on the end. In operation, the manned craft would approach the unmanned vehicle along the spin axis of the latter, spin up the tongs to match the satellite's rotational rate, and then grasp it as if it were standing still. Once grappled, the unmanned satellite could be spun down to match the manned craft's rotation rate and then returned to the Space Station for work. A prototype of this device has been tested in simulations at the Marshall Space Flight Center.

MAINTENANCE & REPAIR

- MAINTAINABILITY IS A TECHNIQUE FOR ACHIEVING HIGH RELIABILITY WITH A MINIMUM OF REDUNDANCY
- MAINTAINABILITY RESULTS IN
  - LOWER WEIGHT
  - LOWER DEVELOPMENT COST
  - MINIMUM RELIABILITY TESTING
- MAINTAINABILITY ESTABLISHES REQUIREMENTS FOR
  - ON BOARD CHECK OUT SYSTEM
  - ASTRONAUTS INVOLVEMENT
  - MAINTAINABLE EQUIPMENT DESIGN
- MAINTAINABILITY IS ENHANCED BY
  - COMPONENT/MODULE COMMONALITY
  - EQUIPMENT RELIABILITY
  - SIMPLICITY IN HARDWARE CONCEPTS
- MAINTAINABILITY IS COMPLEMENTED BY REDUNDANCY

NASA HQ MF70-6100
5-25-70

SLIDE 12

MAINTENANCE AND REPAIR

Maintainability will be an exceedingly important engineering question on the Space Station mission, because the mission will be so long that our previous methods of assuring system reliability will become impractical. Hitherto, our approach has been to provide manned spacecraft systems which are very unlikely to fail within the duration of their missions and which are redundant in all critical areas so that the mission will not be compromised if a failure of reasonable dimensions should occur. With a system as complex as the Space Station and a five-year mission, however, we are constrained to follow the approach of maintaining on-board equipment to prevent failures and repairing any failures that occur.

Slide 12 summarizes the main features of this approach and illustrates the pervasive effects it has on the overall system. Designing for maintainability can give us a simpler, more practical Space Station system than the brute-force approach of trying to achieve reliability over five years of operation, but it will require us to provide means of checking out the whole system repeatedly in flight, it will call for radical new departures in equipment design, and it may involve considerable amounts

SLIDE 12 (continued)

MAINTENANCE AND REPAIR

of crew time, particularly in the early "shakedown" phase of the mission.

Our concept for this activity is to have the crew apply the maintenance, fault detection, and repair procedures planned for the Space Station on experimental equipment that duplicates the maintenance requirements of the Station's critical operational systems.

CREW ACTIVITIES FOR MAINTAINABILITY EXPERIMENTS

- NORMAL SYSTEM MONITORING AND SCHEDULED MAINTENANCE
  - ASSURE DESIGN PERFORMANCE
- INDUCE PLANNED FAILURES AND REPAIR SYSTEM
  - CHECK FAILURE DETECTION APPARATUS, MAINTENANCE PROCEDURES, IN ZERO-G
- MAINTAIN AND REPAIR SYSTEM IN EVENT OF UNSCHEDULED MALFUNCTION
  - ADEQUATE SPARES PROVIDED TO ASSURE VALID TEST

NASA HQ MF70-6098
5-25-70

SLIDE 13

CREW ACTIVITIES FOR MAINTAINABILITY EXPERIMENTS

As shown in this slide, the crew activities for an experiment in maintainability would include both preventative and remedial maintenance. The most important part of the experiment would be to test the adequacy of our plans to deal with equipment failures so that we can be confident of our readiness to deal with contingencies that may arise with operational systems later in the mission. For this purpose, planned failures could be induced in the test equipment, either by including special short-lived parts or through what one might term "programmed sabotage" by the crew. The repair team would then be required to find the trouble and repair it, and the results of the exercise would show whether the tools and procedures would be adequate in the event of a critical breakdown. An alternative approach to gaining valid experience with unscheduled maintenance might be to perform accelerated life tests on the experimental equipment before the flight, so that when it was launched it would be in approximately the condition expected for the operational equipment after three or four years of use.

Depending on the results of such experimental evaluation, it might prove desirable

SLIDE 13 (continued)

CREW ACTIVITIES FOR MAINTAINABILITY EXPERIMENTS

to perform further experiments with modified equipment, tools, and methods, or even to modify the operational systems in flight. In any event, it seems likely that work to increase the effectiveness of maintenance and to reduce its impact on crew time and other support will be continuous during the Space Station mission, and that some of this work will be done in space as well as on the ground.

28

MATERIALS SCIENCE AND MANUFACTURING IN SPACE

BROAD OBJECTIVES

- DEVELOP THE TECHNOLOGY NEEDED TO MAKE SPACE MANUFACTURING POSSIBLE

- USE SPACE LABORATORIES TO SOLVE IMPORTANT PROBLEMS IN MATERIALS SCIENCE AND TECHNOLOGY

- WHEN APPROPRIATE, PRODUCE PRODUCTS IN SPACE FOR USE ON THE GROUND

NASA HQ MF70-6091
5-25-70

SLIDE 14

MATERIALS SCIENCE AND MANUFACTURING IN SPACE

BROAD OBJECTIVES

In contrast to the research programs discussed in the first part of this presentation, the Materials Science and Manufacturing in Space program is intended to lead to private use of space facilities for research and production operations. Obviously this ultimate objective can only be achieved when our orbital facilities expand enough to permit rental of space and support of privately employed technicians, or at least hiring of the crew's services. However, the initial Space Station module will be avital intermediate step toward that goal, because it will support the development of the technical basis for such future operations.

We expect some of the program's benefits to come from use of space laboratory facilities to gain scientific understanding of materials behavior that may have large effects on process technology used on the ground. For example, studies of solidification in the absence of convection can clarify questions about how the grain structure of cast ingots can be controlled, which could affect all of terrestrial metallurgy.

SLIDE 14 (continued)

MATERIALS SCIENCE AND MANUFACTURING IN SPACE

Similarly, studies of chemical reaction kinetics in liquids and gases will be simpler in space and may lead to improved design of chemical plants and new processes on the ground, as well as novel ways of performing chemical reactions in space.

30

MATERIALS SCIENCE AND MANUFACTURING IN SPACE

SPECIFIC OBJECTIVES

- DEVELOP APPARATUS AND EXPERIMENTAL TECHNIQUES FOR MATERIALS RESEARCH AND DEVELOPMENT IN SPACE
- SECURE INVOLVEMENT BY THE INTERNATIONAL INDUSTRIAL AND SCIENTIFIC COMMUNITY
- DURING THE 1970'S DO RESEARCH TO DEFINE SPECIFIC PROSPECTS FOR SPACE MANUFACTURING AND TO ADVANCE MATERIALS TECHNOLOGY
- IN EARLY SPACE STATION OPERATIONS DEVELOP INITIAL PROCESSES AND/OR PRODUCTS
- ESTABLISH A SUITABLE GOVERNMENT - INDUSTRY RELATIONSHIP TO ENABLE PRIVATE USE OF FACILITIES IN SPACE
- ULTIMATELY ESTABLISH SPACE FACILITIES FOR COMMERCIAL RESEARCH AND MANUFACTURING

NASA HQ MF70-6102
5-25-70

SLIDE 15

MATERIALS SCIENCE AND MANUFACTURING IN SPACE

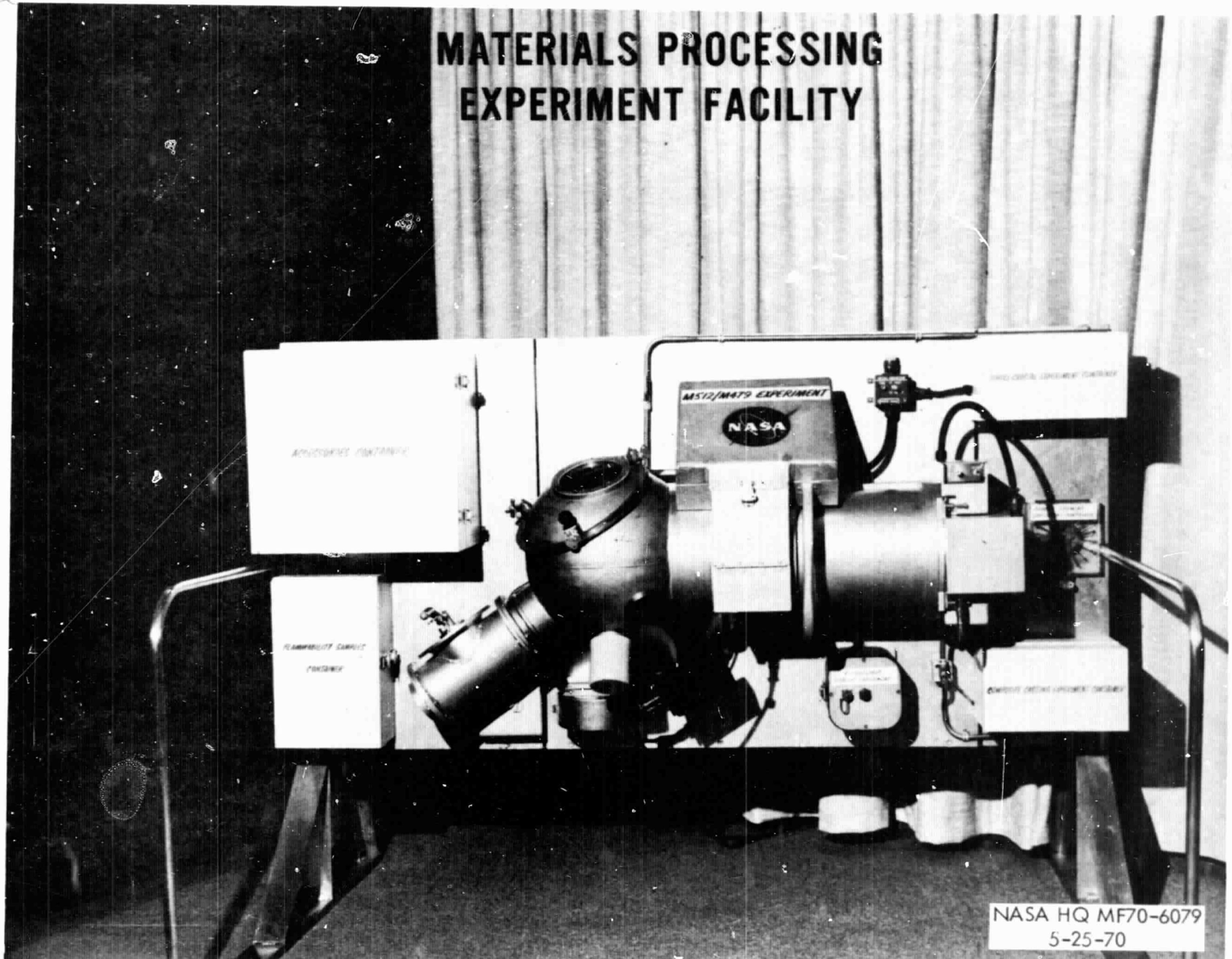
SPECIFIC OBJECTIVES

The specific objectives of the proposed program are somewhat time phased with things that should be done early listed first. The important point here is that the program has two main jobs to do:

1. It must develop apparatus technhology and experimental techniques so that sophisticated materials research and process development work can actually be performed in space.

2. It must support the kind of R&D work that can lead to discoveries and inventions of such importance that space manufacturing will be economically viable and space experimentation will come to be a permanent feature of materials research.

These objectives will require the services of creative minds in scientific and industrial establishments on an international scale. They require a continuing research and engineering program that makes enterprising use of flight opportunities as they arise, but which looks toward the end objectives of the program rather than toward the accomplishment of individual flight experiment programs.

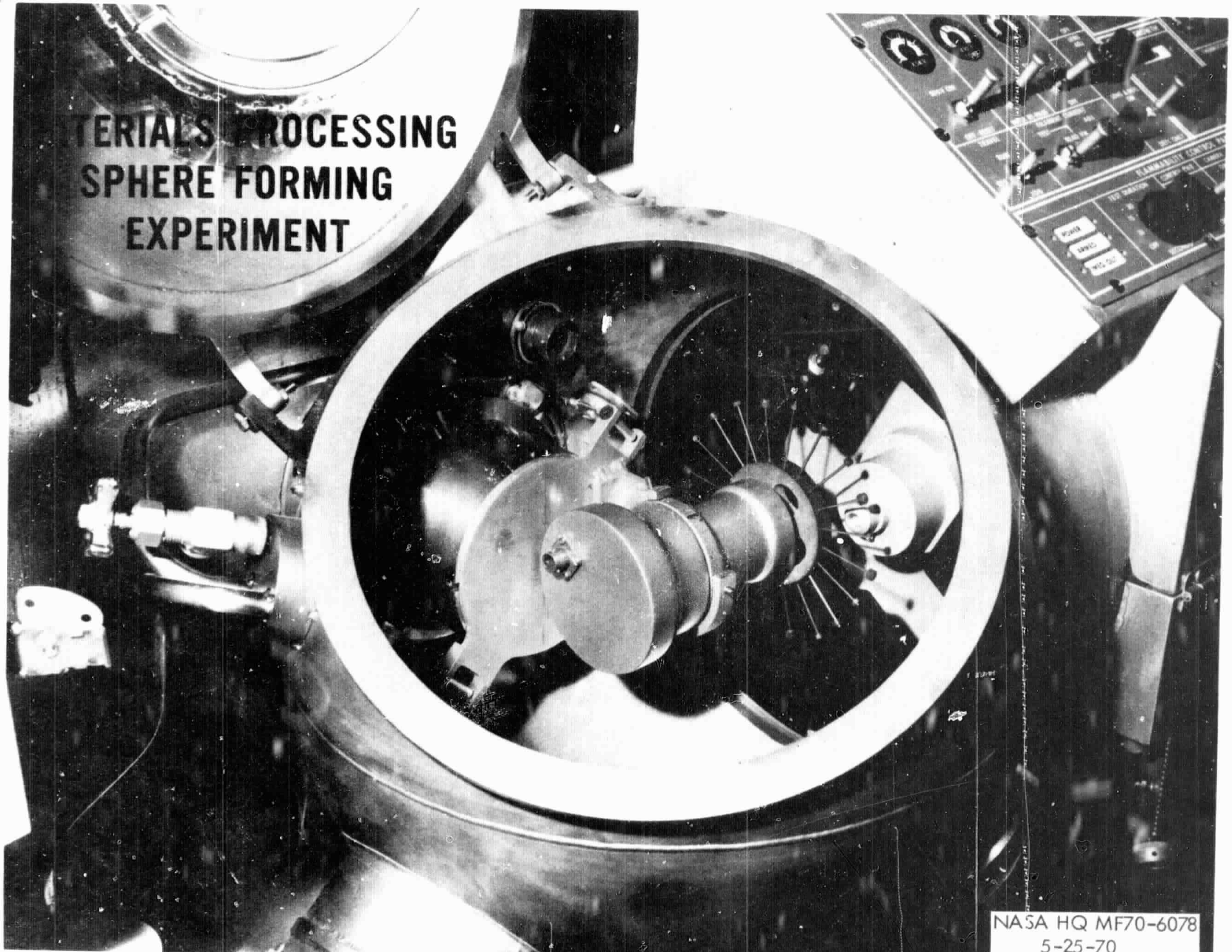

MATERIALS PROCESSING
EXPERIMENT FACILITY
M512/M479 EXPERIMENT
NASA
NASA HQ MF70-6079
5-25-70

SLIDE 16

MATERIALS PROCESSING EXPERIMENT FACILITY

This slide shows a mockup of a facility which is being developed by the Skylab Program for materials processing in space experiments, as it will be mounted in the Multiple Docking Adapter at the forward end of the workshop. It consists of a spherical vacuum chamber, which will be evacuated by venting to space through the pipe projecting downward at the left, and a batter-powered electron beam welding unit which is in the cylindrical section to the right of the vacuum chamber. The unit's control panel is in the box with the NASA emblem on it in the center, and the facility incorporates various supporting services such as water, spacecraft power outlets, and the black motion picture camera which is mounted on a viewport in the front of the chamber. This facility is presently planned to implement six different experiments, and two or three others are currently being developed for it. The six experiments already approved include tests of welding and brazing techniques, three simple experiments on metal solidification and crystal growth under weightless conditions, and a series of tests of the flammability of various materials.

54


TERIALS PROCESSING
SPHERE FORMING
EXPERIMENT
NASA HQ MF70-6078
5-25-70

SLIDE 17

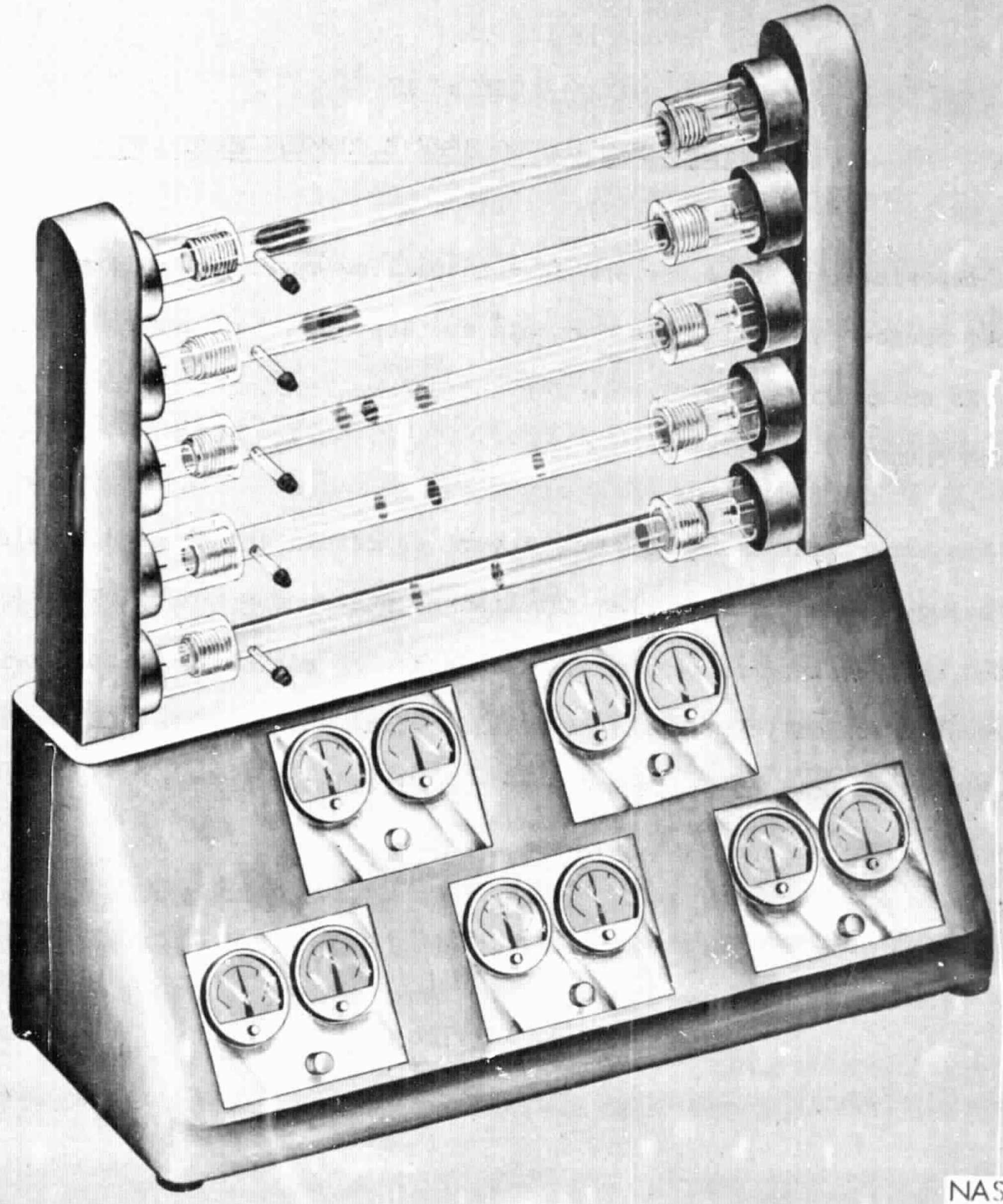
MATERIALS PROCESSING SPHERE FORMING EXPERIMENT

Each experiment will be performed by installing appropriate fixtures inside the vacuum chamber and using the controls and supporting resources of the main facility. As an example, the fixture for the Sphere Forming experiment is shown mounted in the chamber.

In this experiment small samples of various metals are mounted on wire supports, or "stings" on a rotating head actuated by a stepping motor. The samples will be melted by the electron beam gun, visible to the right of the sample assembly, and allowed to solidify; post-flight metallurgical examination will show whether the weightless conditions present during the experiment affected the grain structure of the solidified samples.

36

ELECTROPHORESIS EXPERIMENT



NASA HQ MF70-6077
5-25-70

SLIDE 18

ELECTROPHORESIS

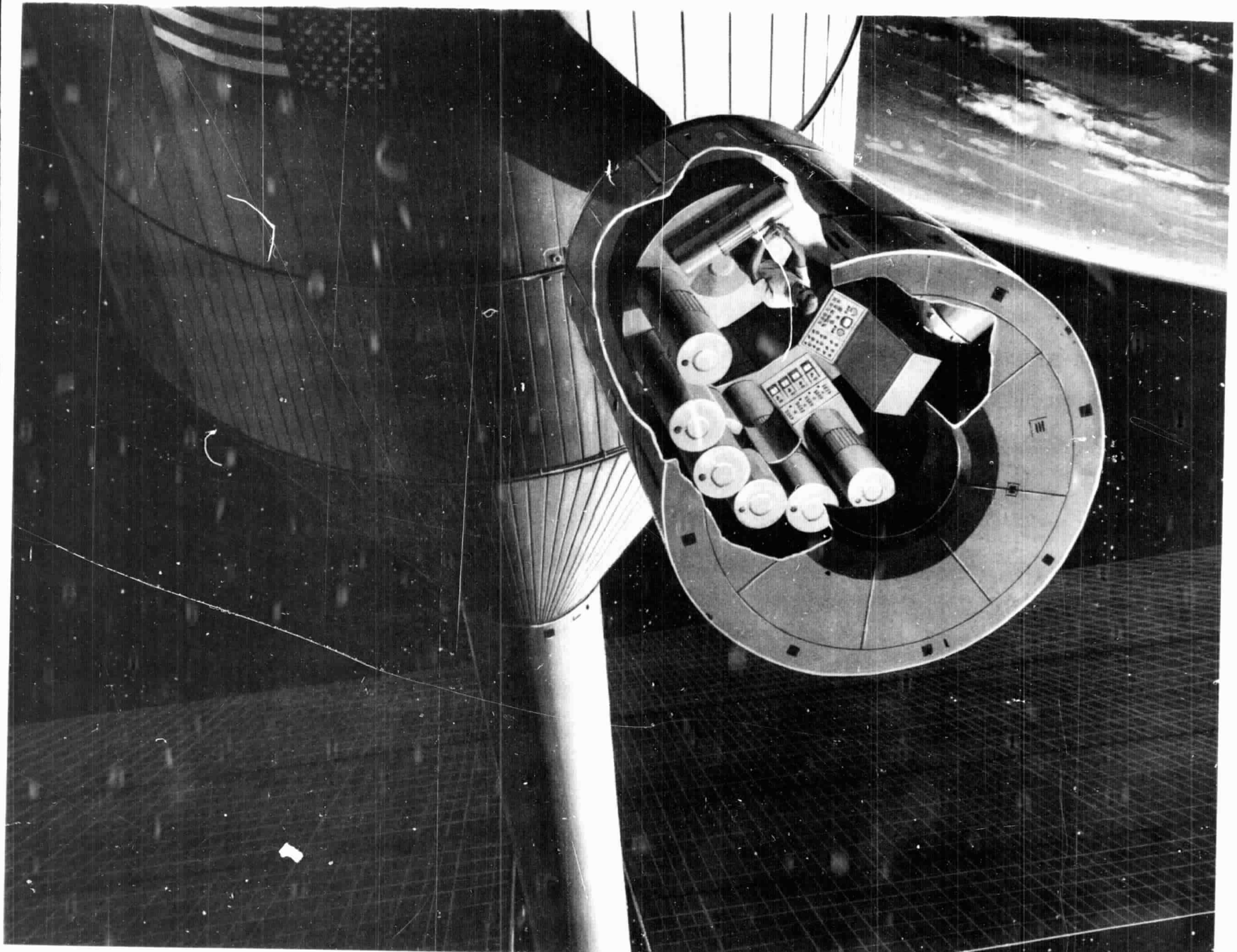
Another process being studied for Space Station application is zone electrophoresis, which is presently used as an analytical tool in earthly biochemistry but may be developed into a practical method of bulk preparation in space.

In a simple version of the process, a narrow band of a mixture of organic molecules or small particles is introduced into a tube containing a buffer solution having a predetermined degree of acidity and an electric field is applied along the axis of the tube, as shown in the top tube in the slide. The molecules or particles in the solution acquire characteristic electric charges depending on the acidity of the solution and migrate with different mobilities in the electric field because they have different sizes and shapes. At later times, as shown in successively lower tubes in the slide, the original mixture separates into distinct bands along the length of the tube, with each band containing molecules having similar combinations of charge and mobility. When the bands are well separated, the desired fraction can be drawn off at an appropriate point, and further purification can be accomplished by repeating

SLIDE 18 (continued)

ELECTROPHORESIS

the process in a solution of different acidity, which can produce different charge distributions on the molecules in the fraction.



SLIDE 19

SPACE STATION MANUFACTURING FACILITY CONCEPT

The Space Station's Materials Science and Manufacturing Facility will include multiple experiment facilities, each capable of supporting a whole class of experiments. The resources of these facilities will be as sophisticated as we can make them in the next five or six years, and each will be used to perform dozens of experiments. Since the experiments themselves will involve little development effort, we expect to be able to open the experiment program to a very wide class of users, including small organizations and perhaps even individual inventors, on much the same basis as a well-equipped research laboratory on earth offers its services.

The experiments to be performed in the facility are planned to include work with supercooled melts of metals and ceramic materials, crystal growth, ultrapurification of materials, containerless solidification and forming of glasses, production of ultrahomogeneous doped semiconductors, production of novel materials from mixtures of immiscible melts or by controlled eutectic solidfication, and similar experiments that may lead to practical space processes or improved understanding of material behavior.

SLIDE 19 (continued)

SPACE STATION MANUFACTURING FACILITY CONCEPT

Initially, the experiments will have to be implemented by the astronaut crew, but we shall be laying the scientific and technical foundations for a future era in which the worldwide scientific and industrial community can make routine use of orbital laboratories and production facilities whenever this is to their advantage.

AEROSPACE MEDICINE RESEARCH PROGRAM
OBJECTIVES

- TO EXTEND MAN'S CAPABILITIES IN MANNED SPACE FLIGHT BY DETERMINING:
  - THE EFFECTS OF SPACE FLIGHT ON MAN AND THE TIME COURSE OF THESE EFFECTS
  - THE SPECIFIC ETIOLOGIES AND MECHANISIMS BY WHICH THESE EFFECTS ARE MEDIATED
  - MEANS OF PREDICTING THE ONSET AND SEVERITY OF UNDESIRABLE EFFECTS
  - THE MOST EFFECTIVE MEANS OF PREVENTION OR CORRECTION OF UNDESIRABLE EFFECTS

- TO OBTAIN SCIENTIFIC INFORMATION OF VALUE TO CONVENTIONAL MEDICAL RESEARCH AND PRACTICE

NASA HQ MF70-6103
5-25-70

SLIDE 20

AEROSPACE MEDICINE RESEARCH PROGRAM

Medical experiments aboard the Space Station will be developed to the evaluation of changes in human function and capabilities which may be induced by very long duration space flight. The Space Station will afford the opportunity to (1) explore in greater detail the functional alterations already encountered in our manned space flight experience, and (2) to accomplish the in-depth monitoring required to ascertain physiological and behavioral effects which have not so far become evident.

The overall objectives of the Aerospace Medicine experiments program exist as two categories. The first is oriented toward the support and enhancement of man and his abilities in manned space flight. The second is oriented toward the advancement of medical science by availing the medical community and its researchers of the opportunity to utilize the peculiar environmental factors of space flight as feasible and relevant to the hypothesis of their research.

42

BIOMEDICAL AND BEHAVIOR EXPERIMENTS

OBJECTIVE
- EXTEND MAN'S CAPABILITIES IN LONG DURATION SPACE FLIGHT
- OBTAIN SCIENTIFIC INFORMATION OR VALUE TO ALL MEDICAL RESEARCH AND PRACTICE

METHOD
- STUDY OF 8 PRIMARY BODY FUNCTION AREAS
  - NEUROPHYSIOLOGY
  - CARDIOVASCULAR FUNCTION
  - PULMONARY FUNCTION AND ENERGY METABOLISM
  - NUTRITION AND MUSCULOSKELETAL FUNCTIONS
  - HEMATOLOGY AND IMMUNOLOGY
  - MICROBILOGY
  - BEHAVIORAL EFFECTS
  - ENDOCRINOLOGY

TECHNIQUE
- IMBLMS

SLIDE 21

BIOMEDICAL AND BEHAVIOR EXPERIMENTS

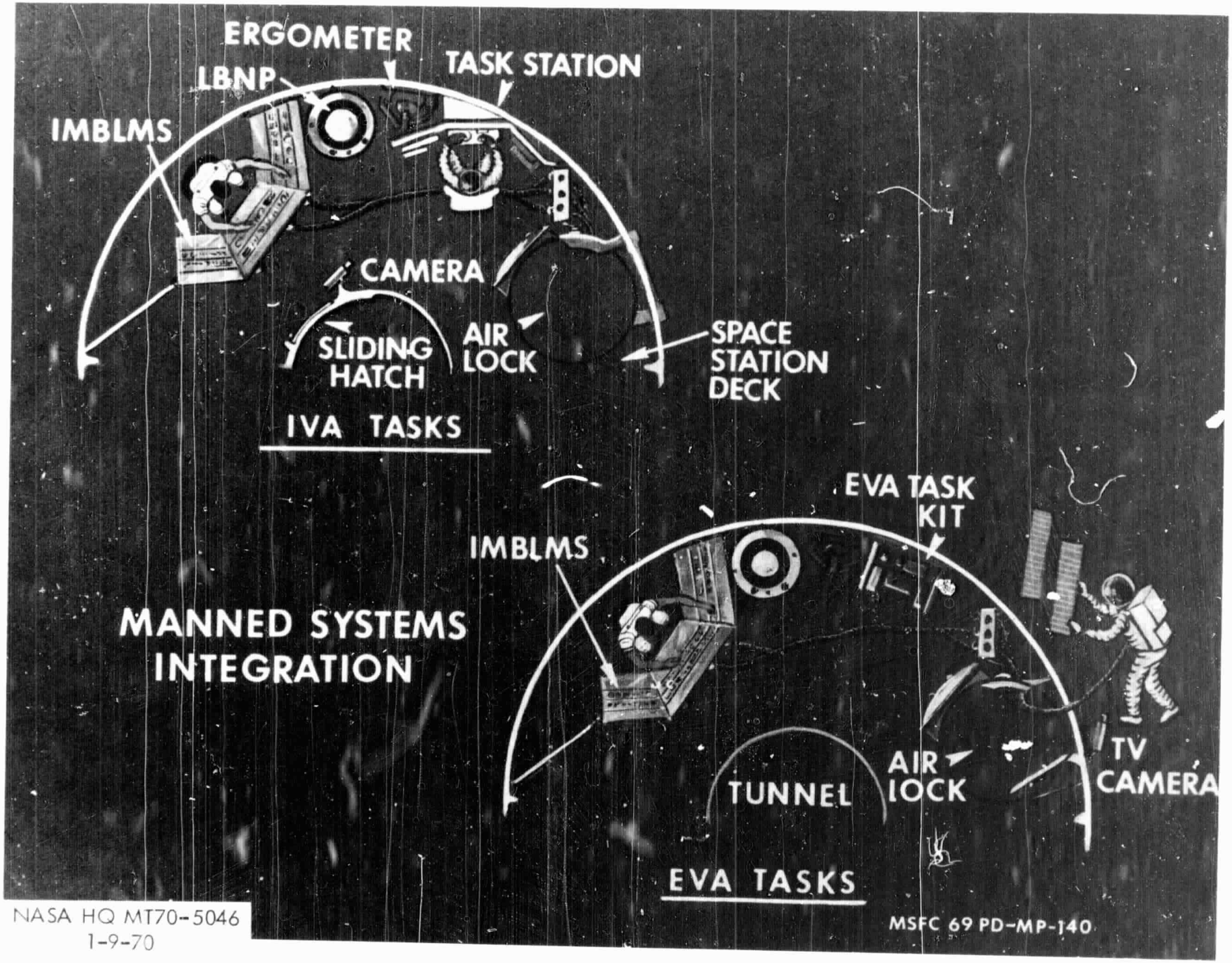
The objectives of the proposed Biomedical and Behavior involve measurements and study of eight primary body function areas as shown.

In pursuing these objectives, basic principles apply which relate clearly to flight program planning.

1. The key variable in the evaluation of man in space is duration of flight.

2. It is important to obtain as great a redundancy of pertinent measurements of individual crew members as is practicable in any given flight configuration to establish statistical validity.

3. A major practical aim of this effort is to utilize these observations for the preparation of appropriate preventive or remedial techniques such as lower body negative pressure, special exercises, and other conditioning methods for maintaining man in a satisfactory condition during future long-duration missions.



NASA HQ MT70-5046
1-9-70

SLIDE 22

MANNED SYSTEM INTEGRATION

This research area has the technical objective of providing quantitative and qualitative information of the use of man and his behavior in space flight and on the moon. Man's capabilities in space systems can be optimized through the following approaches:

1. The identification of inflight tasks which can make optimum utilization of man's presence;
2. The determination of optimal measurement techniques required to assess crew proficiency;
3. The identification of crew skills and training needed to insure optimal performance;
4. The development of design requirements, equipment and techniques for critical operations such as command, control, rescue, transfer, assembly, maintenance, and repair inside and external to the space vehicle;
5. The extension of extravehicular performance design information and the development of effective work aids and translation devices.

46

LIFE SUPPORT AND PROTECTIVE SYSTEMS

THE EXPERIMENT PROGRAM CURRENTLY UNDER STUDY INCLUDES THE FOLLOWING RESEARCH AREAS:

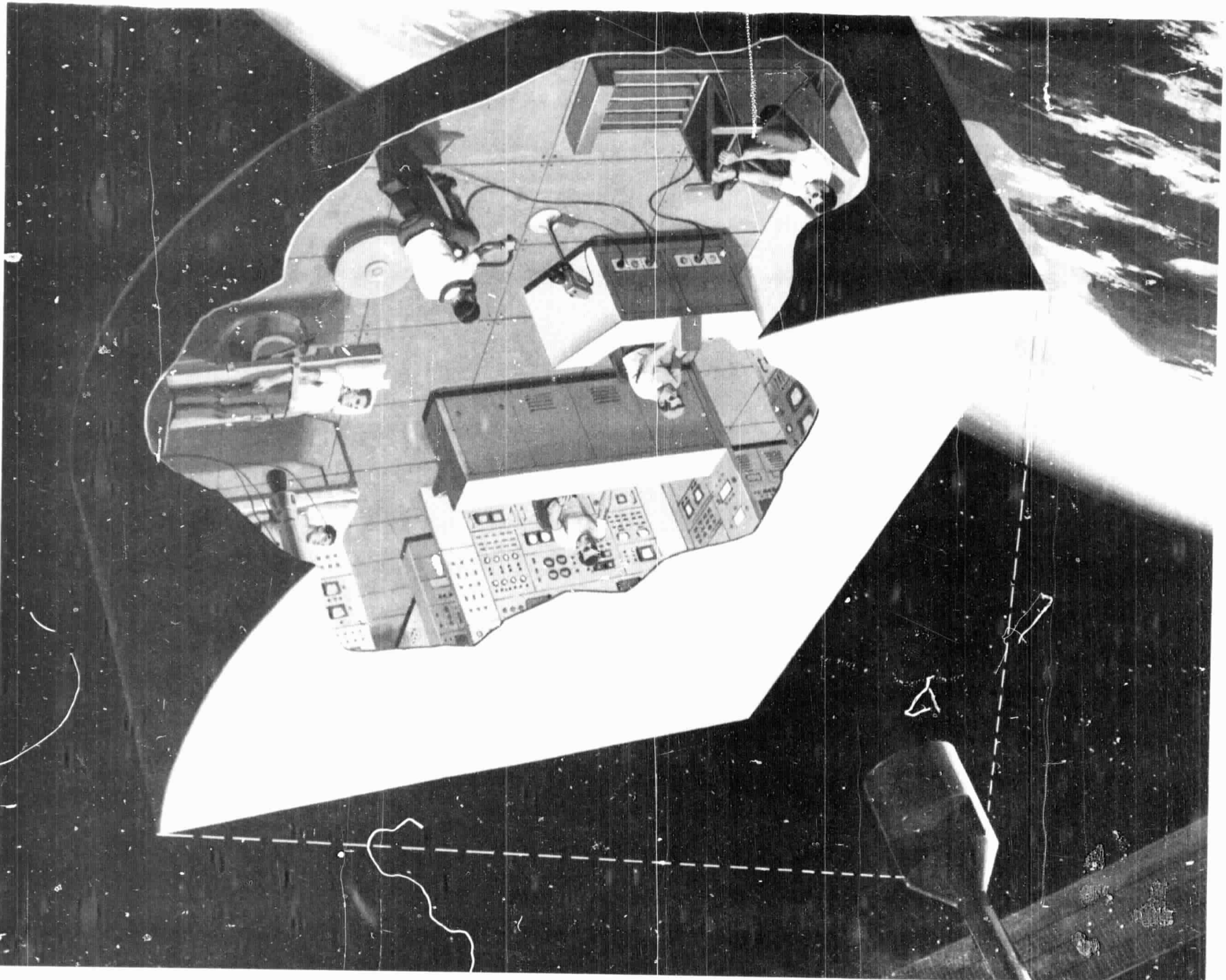
- WATER MANAGEMENT
- WASTE MANAGEMENT
- THERMAL CONTROL
- PERSONAL HYGIENE AND SANITATION
- ATMOSPHERE SUPPLY, CONTROL AND OXYGEN REGENERATION
- CARBON DIOXIDE REMOVAL
- TRACE CONTAMINANTS CONTROL
- ASTRONAUT PROTECTIVE SYSTEMS
- SUBSYSTEMS INTEGRATION
- CLOSED LIFE SUPPORT SYSTEMS
- SENSORS AND INSTRUMENTATION
- FOOD MANAGEMENT
- MAINTENANCE AND REPAIR

NASA HQ MF70-6097
5-25-70

SLIDE 23

LIFE SUPPORT AND PROTECTIVE SYSTEMS

The objective of life support and protective systems technology is to provide a controlled and physiologically acceptable environment for flight crews during all phases of a space mission. In order to accomplish this, research and experimentation in a wide variety of areas is planned for the Space Station using the IMBLMS and related instruments and experimental devices.



SLIDE 24

INTEGRATED MEDICAL AND BEHAVIORAL LABORATORY MEASUREMENT SYSTEM (IMBLMS) CONCEPT

The IMBLMS is a highly flexible and sophisticated laboratory system to accommodate the Medical and Behavioral measurements required for all prepared experiments as well as those anticipated for the future. It is basically a rack and module system which can be assembled into working consoles according to the requirements of the spacecraft and the Medical/Behavioral experiments program for any particular mission. Hardware modules or submodules for specific experiments can be developed to fit the specifications of the IMBLMS and utilized on an "as needed" basis for any particular mission. The flexibility afforded by the modular approach will thus significantly reduce lead-time requirements,enhance in-flight maintenance, and enable the relatively inexpensive introduction of updated techniques and equipment. The IMBLMS will consist of five functional elements: (1) physiological, (2) behavioral, (3) biomedical, (4) microbiological, and (5) data management. For the Space Station, the IMBLMS will be composed of two or three consoles plus four to six pieces of peripheral equipment hard mounted to the spacecraft. Examples of the peripheral equipment are

SLIDE 24 (continued)

INTEGRATED MEDICAL AND BEHAVIORAL LABORATORY MEASUREMENT SYSTEM (IMBLMS) CONCEPT

the bicycle ergometer, rotating litter chair, body mass measurement system, and lower body negative pressure device.

END

DATE

FILMED

MAY 4 1971